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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(Case No. 01-461)

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In the Application of:	)	
	)	
Stuart William Arundell Hunt	)	
	)	**Confirmation No. 6699**
Serial No.: 09/827,735	)	
	)	**Group Art Unit: 2879**
Filing Date: April 6, 2001	)	
	)	
For: Calibration Techniques in Flying Spot Scanners and Telecine Machines	))	

Commissioner for Patents
Washington, D.C. 20231

SUBMISSION OF CERTIFIED PRIORITY APPLICATION

Dear Sir:

Applicant respectfully submits the enclosed certified copy of priority United Kingdom patent application No. 0008662.9 for the above-captioned U.S. patent application.

Respectfully submitted,

McDONNELL BOEHNEN HULBERT & BERGHOFF

Dated: May 24, 2001

By: Lawrence H Aaronson

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
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Stuart William Arundell Hunt

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Confirmation No. 6699

Group Art Unit: 2879

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Washington, D.C. 20231

TRANSMITTAL LETTER

Sir:

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   A. Submission of Certified Priority Application;
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3. Please charge any additional fees or credit overpayment to Deposit Account No. 13-2490. A duplicate copy of this sheet is enclosed.

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By: Lawrence H. Aaronson
Lawrence H. Aaronson
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Dated 24 APR 2001

Patents Form 1/77

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01/7700 0.00-0008662.9

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The Patent Office

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The Patent Office
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Gwent NP9 1RH

1.	**Your reference**	6.15\72666
2.	**Patent application number** *(The Patent Office will fill in this part)*	0008662.9 — 07 APR 2000
3.	**Full name, address and postcode of the or of each applicant** *(underline all surnames)*	Innovation TK Limited Scott House Hagsdell Road Hertford Hertfordshire SG13 8BG
	Patents ADP number *(if you know it)*	6719280002
	If the applicant is a corporate body, give country/state of incorporation	GB
4.	**Title of the invention**	Calibration Techniques in Telecine Machines
5.	**Name of your agent** *(if you have one)*	Frank B. Dehn & Co.
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	179 Queen Victoria Street London EC4V 4EL
	Patents ADP number *(if you know it)*	166001
6.	**If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and** *(if you know it)* **the or each application number**	**Country** / **Priority application number** *(if you know it)* / **Date of filing** *(day / month / year)*
7.	**If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application**	**Number of earlier application** / **Date of filing** *(day / month / year)*
8.	**Is a statement of inventorship and of right to grant of a patent required in support of this request?** *(Answer 'Yes' if:* *a) any applicant named in part 3 is not an inventor, or* *b) there is an inventor who is not named as an applicant, or* *c) any named applicant is a corporate body.* *See note (d))*	Yes

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Description	11
Claim*(s)*	
Abstract	
Drawing*(s)*	1 + 1

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Priority documents	
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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. **I/We request the grant of a patent on the basis of this application.**

Signature **Date** 7 April 2000

12. **Name and daytime telephone number of person to contact in the United Kingdom**

Michael J. Butler
020 7206 0600

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Calibration Techniques in Telecine Machines

This invention relates to calibration techniques in telecine machines.

There have been for many years systems to convert cinematographic motion picture film into electrical signals for television broadcast or video cassette production. These machines are commonly referred to as 'Telecine' machines. Such examples of these machines includes the 'URSA' telecine from Cintel International Ltd, and the 'SPIRIT' Telecine from Phillips Digital Video in Darmstadt, Germany, and the applicant's own 'Millenium Machine' These telecine machines need to 'scan' the cinematographic film. This is accomplished in the SPIRIT system by the use of a CCD (Charge Coupled Device) and more relevantly to this invention, by the use of a CRT (Cathode Ray Tube) in the Cintel International URSA machine.

The use of CRT (Cathode Ray Tubes) for the use of film scanning is not new. It has been known at least as long ago as 1975, where it was used in the Rank Cintel Mk III Telecine. In this system, the film is 'scanned', by the imaging of a scanned 'raster' patch on the front of the CRT being imaged onto the film, and the collected light transmitted through the film being collected by photosensitive devices. These photosensitive devices are quite often photomultiplier tubes. These photomultiplier tubes convert the incident light into an electrical signal that is dependant on the amount of light, and thus dependant on the density of the film at any point scanned. It is well known that such devices require a voltage to be applied to them, and that the signal resulting from these devices is dependant on the voltage level applied to the device.

It is often necessary to calibrate this light

measuring system, for many reasons. Firstly it is desirable to have a measurement of the actual density of the film present in the telecine gate, rather than just a relative measurement of how much lighter or darker one portion of the film is with respect to another. Secondarily, the light emitted from the CRT is variable, and as a CRT ages, the light emitted from the phosphors tends to decrease for a given drive current. Secondly, the signal received from the photomultipliers is dependant on the electrical gain provided on these devices. There is also potentially an 'aging' effect in the photomultiplier tubes, resulting in less signal for a given amount of incident light and gain voltage.

Telecine machines are often used in conjunction with Telecine programmers. Such devices include the 'POGLE Platinum' from Pandora International Ltd., of Northfleet, Kent, England. These devices are used to 'store' control adjustment parameters for later recall. These parameters relate to editorial alterations to particular scenes (or even film frames) of a given film reel. Naturally, it is desirable to be able to view the 'red' colour of a Woman's dress from a particular scene on a roll of film, and several weeks later to view that same scene, with the same stored control parameters, and see the same 'red' hue. Thus the stored telecine parameters must produce the same rendered colours day-in and day-out. The electrical signal necessary to be applied to the photomultipliers to produce that hue from that film will vary slightly, according to the age of the photomultiplier devices, thermal drift in the control circuitry, and thermal effects in the photomultiplier. It can be seen that some 'calibration' mechanism is necessary to be able to reproduce hues repeatably and reliably.

There have been attempts to regulate the CRT system. For example, it has been known for many years to use a technique called 'burn correction'. This basic

technique was disclosed in the now abandoned German patent application DE-OS-25 25 073, published on 18th December 1975. Burn correction works by measurement of the emitted light from the CRT at any moment in time both directly from the CRT face, to derive a 'burn' signal, and also through the film, to derive an image signal. Thus if the part of the CRT face we are using (or indeed the whole CRT face) is emitting less light than elsewhere (or previously) then we can correct for this in the light collected after passing through the film. For example, if the CRT light were to drop by 10% as measured by the 'burn' corrector, the light collected by the image sensing photomultipliers would be measured relative to this '90%' light value rather than the assumed 100% that would be assumed without 'burn' correction. Having effectively provided a control mechanism to ensure that the CRT at least appears to give a constant amount of light, the area that we wish to describe here is the calibration of the light sensors.

There have been several proposals in the attempt to calibrate the photomultiplier response to the light level from the CRT. One such proposal is disclosed in patent GB 2 241 625, by Rank Cintel Ltd. This method teaches how to carry out a 'two point calibration' for the system. The steps for this are to set the CRT beam current to a nominal 'low' level, typically 15 Microamps, and to then alter the PEC drive voltage to produce a 'peak electrical signal'. This is repeated with a 'maximum' beam current, typically 300 microamps, where the PEC drive voltage is again varied to get the 'peak electrical signal'. This data is used to create a 'straight line relationship' between light level and PEC drive voltage.

This method is inherently flawed, as the characteristic of light level to drive voltage departs significantly from a linear characteristic at certain

drive levels.

Viewed from one aspect of an invention disclosed herein, therefore, there is provided a method of calibrating the light system in a telecine machine using a cathode ray tube light source and a photosensitive detector, wherein at a first level of light transmitted to the photosensitive detector a control signal to the photosensitive detector is adjusted to obtain a predetermined video signal, and the value of the control signal is noted; at a plurality of other levels of light transmitted to the photosensitive detector, the control signal to the photosensitive detector is adjusted to obtain the predetermined video signal, and the values of the respective control signals are noted; and a lookup table is created of calibration values for different levels of light, so that during normal operation of the telecine machine values in the table can be used to obtain calibration information for different levels of light transmitted to the photosensitive detector.

The different light levels could be obtained by inserting filters of different known density in the light path. In such a method the CRT drive current would be set at full beam, and the PMT control voltage adjusted to obtain a predetermined video signal, say of half video full volts. This starting level is not really important, as long as the level chosen is not too near full video or zero video. A known optical filter that would, for example, absorb one half of the light is inserted in the light path. The PMT gain is increased in this condition to obtain half video signal. Similarly, an optical filter that absorbs three quarters of the light can be used, and the PMT gain adjusted to a point where the image signal is still one half of the maximum video signal. This could be repeated to produce a calibrated response for the telecine at all, or at least a large number of, light levels. This characteristic could be stored, and utilised as a 'look up' table in a

digital circuit. Ideally, this would be repeated at many points. These points would typically be at 1dB (decibel) intervals

This technique, unlike the technique described in GB 2 241 625, can be implemented with the 'burn correction' enabled because the drive current to the CRT is not varied. It is therefore a method of calibrating the PMTs in a realistic operational state, rather than in an unrepresentative state. However, it is not an entirely satisfactory technique. It is undesirable to use reference filters for many reasons, including the time taken, the manual intervention necessary, and the fact that the 'reference' filters may be easily damaged, and will in time change in density. A great many filters would be needed to produce a good characteristic.

The actual technique described in GB 2 241 625 does not use filters, although because it involves only maximum and minimum measurements it might be a feasible technique. In GB 2 241 625 the light level is varied by varying the drive current to the CRT. However, in practice this requires that "burn correction" be disabled during the calibration process.

A 'burn' (or grain) correction system is intended to regulate the light output of the CRT, and detects the light output from the CRT directly, before it passes through the film. If the CRT beam current were to be decreased from full drive to one half drive during a calibration step, the 'burn' detector will notice that the reference level has dropped to one half, and the image signal will be corrected to allow for this, thus resulting a full scale image signal at all beam currents. Clearly this will not allow the production of a representative characteristic.

However, disabling 'burn' correction during calibration will not give reliable results. 'Burn' correction alters the characteristics of a telecine significantly, as amongst other things it corrects for

the phenomenon of CRT 'grain'. This effect is caused by the fact that although the phosphor used in the CRT is a fine powder, it still has a granular structure. Thus there is a small random variation in light level as the CRT spot passes along the scan line, as phosphor granules are hit both centrally and peripherally. These signal variations occur differentially in all three colours, as the phosphor used for telecine CRTs is often composed of three or more separate phosphors. It is hardly surprising that calibrating the PEC system with 'burn' correction disabled, and then enabling burn correction for the transfer of images produces non-optimal results.

According to one aspect of an invention disclosed herein, therefore, there is a provided a method of calibrating the light system in a telecine machine using a cathode ray tube light source, a photosensitive detector, and a burn corrector system, the burn corrector system being operative during the calibration and serving to adjust a control signal for the photosensitive detector in accordance with variations in the output of the cathode ray tube, wherein at a first level of drive current for the cathode ray tube a control signal to the photosensitive detector is adjusted to obtain a desired video signal parameter, and the value of the control signal is noted; at a plurality of other levels of cathode ray tube drive current, the control signal to the photosensitive detector is adjusted to obtain desired video signal parameters, and the values of the respective control signals are noted; and a lookup table is created of calibration values for different levels of light, so that during normal operation of the telecine machine values in the lookup table can be used to obtain calibration information for different levels of light transmitted to the photosensitive detector; wherein the video signal parameters are virtual video signal levels taking into

account signals from the burn detector.

By working with virtual signal levels, in a software emulation, it is possible to have burn correction operative. If this was done and real video signal were used, they would be out of range.

This and other aspects of the invention will be described in more detail below and with reference to the accompanying drawing which is a diagram of a telecine system for use in accordance with the invention.

In implementing the invention, a first step will usually be to disable the 'shading correction' aspects of the telecine. Shading correction is a position based correction to allow for (amongst other things) non linear illumination of the optical system, and has been known since at least 1975 as incorporated in the Rank Cintel Mk III telecine.

The next step is carried out with no film present but with the burn correction system operative, measuring directly the light output from the CRT. The CRT is driven at full drive current to provide maximum light output. A small illumination patch at the centre of the tube (typically 50 x 50 pixels) is analysed to measure both a burn signal (value B) and an image signal (value I). For this example the initial value of I may be 0.5. In practice, any value between 0 and 1.0 could be used. Note that having the value of I too near to 1.0 is not desirable as 'headroom' is needed. For example, it may be desirable to not reproduce 'empty gate' as 'peak white' video.

Next, there is derived a ratio (Value R) of these two values, being the Image value (I) divided by the Burn value (B)

Next, the CRT beam current is set to a level of approximate known ratio to the previous level. This ratio could be 1/2, although it must be understood that other values could be used. In the case of a CRT drive current of 150 microamps (half the 300 microamps full

drive current) twice the gain will be needed at the photomultiplier to produce the nominal 0.5 image signal (uncorrected). However, since the burn correction is enabled, this burn corrected signal will be a nominal 1.0. If this process is repeated, and for example the CRT drive current is again halved, then the 'burn corrected' image signal will tend to 2.0 of full scale video. Thus 'overload' would happen, and no sensible measurements could be made, as video electronic circuits cannot handle more than 'full scale' video

The present invention involves a system which works with a 'virtual' image signal, with burn correction, outside the useable operational range. This can be derived by a software implementation of the burn circuitry. In software implementations of algorithms it is possible to exceed the levels of electronic video signals. It will be shown in the example below that whilst the corrected video signal would be 'out of range' in terms of electrical signals, both the uncorrected signal and the 'burn' signal are producing tangible values. Whilst the corrected video signal would be well in excess of the maximum values allowed, it is possible to utilise the 'in range' uncorrected signals and 'in range' values to feed into a software model of the burn correction system, which will calculate the value of the video signal that would occur if the video circuitry had sufficient range.

The CRT beam current can then be reduced further, by typically another factor of two, and the burn corrected signal for this light level calculated according to the algorithms above.

Whilst the examples below have only a few points, although it is realised that for best effect a large number.

A typical table is produced below, Table 1. Note that for the purposes of this example, the tube is 'perfect' (ie there is no 'burn' on the tube anywhere,

so R always is equal to 1.0) and produces a full output at all points.

TABLE 1

CRT Beam current	Burn Signal	Uncorrected Video signal	Burn corrected Video signal
300uA	1.0	0.5	0.50
150uA	0.5	0.5	1.0
75uA	0.25	0.5	2.0
37.5uA	0.125	0.5	4.0
18.75uA	0.0625	0.5	8.0

From table 1, it can be seen that for CRT beam current both the burn signal and the uncorrected video signal are measured. Software emulation is then used to determine the theoretical (as opposed to actually measured) burn corrected video signal.

It is important to realise that the absolute values in the table are merely examples. The important thing to understand is that this system considers ratios of the burn to uncorrected video. For example, the second value in the table (for 150uA) could be a burn of 0.45 and an uncorrected video signal of 0.45, as this combination still gives a burn corrected signal of 1.0

Considering now an 'imperfect tube (or at least a point or series of points on a tube that is imperfect, the burn circuitry will denote that these points are imperfect and correct as follows, with reference to Table 2:-

TABLE 2

CRT BEAM current	Burn Signal	Uncorrected Video signal	Burn corrected Video signal
300uA	0.9	0.45	0.50
150uA	0.45	0.45	1.0
75uA	0.225	0.45	2.0
37.5uA	0.1125	0.45	4.0
18.75uA	0.0562	0.45	8.0

This characteristic is then 'plotted' to construct a table between light level and PMT gain voltage. This table can be used as a 'lookup table', and say what PMT voltage is necessary on one day to repeat the same 'picture appearance' for given editorial settings as was derived on a previous day.

In a further implementation, this process can be automated, and initiated automatically at the request from the operator. In yet another implementation, this process could be repeated automatically using very fast hardware / software in the 'frame blanking' interval, where no active picture is being scanned.. The very fast hardware is necessary, as there are only 49 'blanked' lines in the present European 625 line system of television transmission, and with a data rate of 25 full frames per second, the blanking interval is only 49/625 x 1/25th of a second, or approximately 3 milliseconds. In High Definition this time is considerably shorter, and may well be of the order of microseconds not milliseconds.

Note that the previously proposed measurements are performed with an 'open gate' (i.e. no film loaded on the telecine). It is of course impossible to remove the film and replace it in 1/25th or 1/30th of a second, so a way of seeing around the film is necessary. This can be accomplished with a 'periscope' like device. An example of this device is shown in Figure 1, which shows a scanning CRT 1, a film 2 in a gate, a lens 3, a photomultiplier tube 4 and a burn correction detector 9. To enable the system to see around the film, mirrors 5, 6, 7 and 8 are used. The system could use 'semi silvered' mirrors at 5 an 6, for example, allowing some of the light to pass around the film, whilst most of the light could pass through the semi silvered mirrors and then through the film.

Alternatively, a part of the surface of the CRT not normally used for scanning the film could be illuminated

in the blanking interval, and used for calibration illumination.

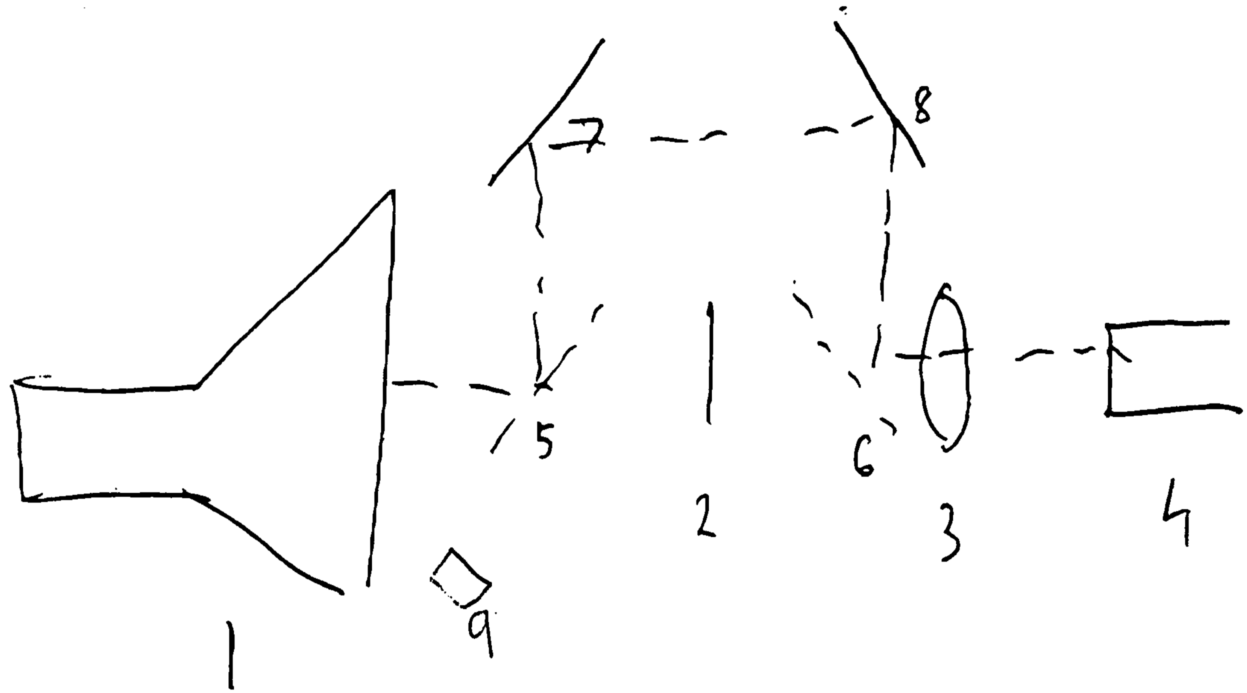
An alternative to updating on every film frame, which has the associated high cost of fast hardware, is to utilise the system described above on a 'daily' basis, and to provide a simple 'update' correction. This may be done in several ways, including measuring one known point, comparing it with a previous value, and determining what to do. One action may be to take no action, as the point measures as before. Another action would be to notice that there has been a small 'drift' and to make a simple scaling correction for this drift. Yet another valid action may be that in the case of a large drift the system may inform the operator that the system is 'out of calibration', and that a full calibration cycle is needed.

The 'periscope' arrangement will be in the short term a very stable device but in the long term the relative transmission of partly silvered mirrors may change. An additional operational feature is to note the relative transmission of the periscope in comparison with the daily 'open gate' measurement. This allows the correction to be made for relative changes in the periscope transmission.

Another important feature of the periscope arrangement is that it is important to never allow video overload of the uncorrected signal to occur. This can be achieved with the choice of suitable neutral density filters to be inserted into the periscope's optical path.

Whilst the invention has been described with reference to one channel of a telecine, in practice the technique can be applied separately to each of the channels of a colour telecine.

FIG 1 – PERISCOPE ARRANGEMENT



1/ – CRT

2/ – FILM

3/ – LENS

4/ – PHOTOMULTIPLIER

5/ + 6/ SEMI-SILVERED MIRRORS

7/ + 8/ FULLY SILVERED MIRRORS